Description of Frequently Used Transportation Models

Tools For Land Use, Greenhouse Emission, Freight And Multi-Modal Regional-Interregional Travel Model Analysis

Each modeling tool discussed below is used to address specific questions, but cannot address all transportation issues. As a result, one model will not address all the current state-of-the-practice in transportation policy, planning, and scenarios needed for local, regional, and statewide application. Understanding the weakness and strength of each model is important since the structural equations, data input specification, and model assumptions are different. Therefore, it is recommended to use more than one model to answer questions that arise when a range of multiple transportation investment actions are being considered. Since both the theoretical and practical aspects of each model below are different, applying them in combination can answer issues that may arise in developing or applying for multimodal alternative transportation policies.

1. Four Step Standard Travel Forecasting Models (Travel Model and CMAQ)

Travel survey data and mathematical models are then used to predict the number of trips generated in each zone, the distribution of these trips (origin and destination), modal shares, and the routes taken for trips. Travel models are typically used in developing an area's long-range transportation plan to predict future traffic volumes based on changes in travel patterns, and to compare forecast volumes to roadway capacities to identify deficiencies and needs. Standard four-step regional travel models can analyze Congestion Mitigation and Air Quality (CMAQ) strategies that can be translated into changes in the number of vehicle-trips by Traffic Analysis Zone (TAZ, i.e., an area-wide employer trip reduction strategy) or changes in transportation network characteristics (i.e., new transit service between two points). Once outputs of the regional travel model are obtained, emission factors (expressed in grams per mile or grams per trip) can be applied to Vehicle Miles Traveled (VMT) and/or vehicle-trips by vehicle type and speed to calculate emission inventory.

2. Statewide Travel Model (Interregional Multimodal & CMAQ/VMT)

The California statewide travel model is a model that addresses urban, regional, and statewide applications. The statewide model incorporates the regional models output (including auto, air, transit, conventional rail, and high-speed rail modes). The statewide model has around 5000+ TAZs and 200,000+ links that encompass all the California corridors and the state highway system. As part of the integrated modeling process, the statewide travel model primarily relies on the urban models of Metropolitan Transportation Commission (MTC), The Sacramento Area Council of Governments (SACOG), Southern California Association of Governments (SCAG), and San Diego Association of Governments (SANDAG), which have all been validated. San Francisco and Los Angeles region metropolitan planning organization (MPO) models were incorporated to include the forecasts of intra-regional trips for these regions. The statewide model also provides interregional trips output (internal-external trips and through trips) to be used as input to the regional models. The statewide travel model can analyze Congestion Mitigation and Air Quality (CMAQ) strategies that are translated into changes in the number of vehicle-trips by traffic analysis zone (TAZ, i.e., an area-wide employer trip reduction strategy) or changes in transportation network characteristics (i.e., new alternative transportation investments). Once outputs of the statewide travel model are obtained, emission factors (expressed in grams per mile or grams per trip) can be applied to VMT and/or vehicle-trips by vehicle type and speed to calculate emission inventory.

3. Tour-based Model (Trip Chaining)

In tour-based models, travel choices for trips within a tour are not treated as independent of one another. A tour-based model is agent-based; that is, both households and individuals are modeled within an object-oriented, micro-simulation (individual within household) framework. In addition, the model is household-based in that inter-personal household constraints on vehicle usage are modeled, and the auto passenger mode is modeled as a joint decision between the driver and passenger(s) to ride-share. Each person is assumed to choose the "best" combination of modes available to execute each tour, subject to auto availability constraints that are determined at the household level. The household's allocation of resources (i.e., cars to drivers and drivers to ride-sharing passengers) is based on maximizing overall household utility, subject to current household resource levels. Therefore, tour-based models provide both trip chaining (tour) and multi-modal trip level analysis.

4. Activity-based Model (Travel Resulted from the Demand for Activities)

As noted earlier, the activity-based approach explicitly recognizes the fact that the demand for activities produces the demand for travel. In other words the need or desire to engage in an activity at a different location generates a trip. Then, once we understand how activities are engaged in the course of a day or a week, a rigorous understanding of travel demand will follow. The model approaches are perhaps the most promising alternative to the current travel forecasting methodology. The model uses a clustering approach to identify groups of similar activity-travel behavior and relates them to household socioeconomic attributes. Minimally, the pattern generation model is offered as a possible replacement to the standard trip generation models. The technique clearly recognizes the complex nature of activity-travel behavior in terms of spatial and temporal constraints, household interactions, and the derived nature of such behavior.

5. Urban Growth Model (Land Use and Transportation)

UPlan is a simple rule-based urban growth model intended for regional or county level modeling. Urban growth models useful in transportation planning are based on geographic information system (GIS) software. UPlan, a simple model written in Arc View, is described for several different applications involving transportation planning and analysis of the growth-inducing effects of new facilities. The needed space for each land use type is calculated from; (1) simple demographics and assignment based on the net attractiveness of locations to that land use (based on user input), (2) the locations unsuitable for any development, and (3) a general plan that determines where specific types of development are permitted.

6. MEPLAN (Land Use and Transportation Interaction)

The MEPLAN model analyzes the spatial economies of regions or cities. MEPLAN is referred to as a model of land-use/transport "interaction." It is a fairly detailed and comprehensive transportation-planning model. The influence of transportation conditions on the location of various land uses is the core to the function and purpose of the model. MEPLAN land use and transportation-interaction models traditionally include models of business-location choice. The mechanisms in the model allow for realistic aggregate assignment of firms to zones, and the resulting impacts that firm location has on the entire modeling system are described. The models use a form of logit function to allocate production activities to zones. Interdependencies in the Social Accounting Matrix, together with trip and land cost data and usage rates, generate a utility function for the attractiveness of purchasing a given sector's output from a given zone. The alternative specific constants and the dispersion parameter are estimated in calibration, based primarily on cost data, trip-length distributions, and arrangement of activity in a calibration year.

7. PLACE3 (Land Use Transportation Design and Estimates CO2)

PLACE3 is an internet-accessed land use and transportation model designed specifically for regional and local governments to help understand how their growth and development decisions can contribute to improved sustainability. It estimates CO2, criteria pollutant, and energy impacts on a neighborhood or regional level for existing, long-term baseline, and alternative land use plans. PLACE3 is currently being used in San Diego, San Luis Obispo, and the six County Sacramento regions to assist both the public participation process and technical analyses efforts for regional planning. The data input requirements are extensive and require a fiscal commitment from local government. The benefits include a tool that can provide immediate outputs to compare various alternatives during public meetings, as well as provide access for local development project California Environmental Quality Act (CEQA) analyses.

8. Integrated Model PECAS (Land Use, Economics, and Transportation)

An integrated model is used to evaluate economic, land use, transportation, and other potential benefits and impacts of various transportation investment decisions. Transportation system features affect household and business location choices, levels of production and trade patterns. These choices manifest themselves in various forms of travel demand to impact the operational performance of the transportation system. Input-Output (IO) models have been widely used to simulate the linkages among industries, and between producers and consumers. These models are demand-driven, in the sense that production levels are adjusted to meet both final and intermediate demands. Traditional IO models have been extended to incorporate spatial desegregation. The application of random utility principles, in the form of logit models for location choices, gave rise to several operational models, including a framework to incorporate variable technical coefficients, and uses exchange zones to clear all markets. An integrated model could be used to better understand various infrastructure investment proposals and policy options.

9. Sustainable Community Model (Community Involvement and Model CO_2 Emission)

Sustainable Community Model (SCM) is a public involvement model that identifies shared values and vision of a community such as transportation, land use and wide implementation of city or regional sustainability goals. How communities are using the Natural Step Framework to develop a shared vision and action plan. The Sustainable Community Model quantifies total carbon dioxide (CO_2) emissions allowing communities the ability to optimize planning decisions that result in the greatest environmental benefit for the least cost. SCM has been used by a number of master planned communities, but it could also be used for neighborhoods and smaller developments. Total CO_2 emissions are based on emissions from energy usage, water consumption, and transportation. SCM uses published data sets for data input such as Air Resources Board's (ARB's) Emission FACtors (EMFAC) for transportation calculations. In general it quantifies total environmental impacts (including energy use, water use, greenhouse gas emissions, air pollution emissions, storm water, transportation impacts, solid waste, and other factors) allowing communities to optimize planning and design decisions that result in the greatest environmental benefit for the least cost.

10. ARB EMFAC (Calculate Emission Rate)

The Emission FACtors (EMFAC) model is used to calculate emission rates from all motor vehicles, such as passenger cars to heavy-duty trucks, operating on highways, freeways, and local roads in California. EMFAC2007 is the most recent version of this model. Both the EMFAC and OFFROAD Models develop CO_2 and Methane (CH_4) emission estimates; however, they are not currently used as the basis for ARB's official Greenhouse gas (GHG) inventory, which is based on fuel usage information. The ARB's official GHG inventory can be found at the link http://www.arb.ca.gov/cc/inventory/inventory.htm.

11. NEMS MODEL (Energy, Economics, Environmental Model)

The National Energy Modeling System (NEMS) is a computer-based energy-economy modeling system of the energy markets. NEMS is used for annual projection of the production, imports, conversion, consumption, and prices of energy. The NEMS model is used to project energy, economic, environmental alternative energy, and transportation policies at the state level. As an annual model, NEMS can also provide the impacts of transitions to new energy programs and policies. The structure of NEMS consists of an integrated modeling system representing all demand sectors of the economy (residential, commercial, industrial, and transportation), including a macroeconomic component and all energy supply sources. NEMS has the following sub modules:

- **The Air Travel Demand** Sub-module forecasts revenue passenger-miles for international and domestic travel.
- **The Freight Truck Sub-module** uses macroeconomic gross outputs by Industrial Classification System in determining VMT.
- **The Miscellaneous Sub-module** includes mass transit, which covers six transit modes: three types of passenger rail—transit, commuter, and intercity; and three types of passenger buses—transit, intercity, and school. Travel is estimated for six transit modes as a function of the relative historical growth rate of passenger-miles of travel.
- **The NEMS Transportation Demand Module** provides wide coverage of the aggregate transportation system including macroeconomic activity module and a module to forecast emissions of the criteria pollutants Sulfur oxide **(SO_x),** nitrogen oxide **(NOx),** hydrocarbon **(HC),** Carbon monoxide **(CO),** and Carbon dioxide **(CO_2).**

12. The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model

The GREET model is intended to serve as an analytical tool to estimate fuel-cycle energy use and emissions associated with alternative transportation fuels and advanced vehicle technologies. The GREET model provides full fuel-cycle emissions analysis, which represents emissions from all phases of production, distribution, and use of transportation fuels. Besides the fuel-cycle, GREET is a vehicle cycle model that estimates emissions and energy use. The strength of GREET is that it analytically compares energy use and emissions from vehicle technologies matched with many alternative fuels, over the entire fuel cycle. Emissions in the model include the following: GHGs (CO_2, methane, and nitrous oxide), NOx, HC, CO, sulfur dioxide (SO_2), and particulate matter (PM). GREET addresses the need for truly comparative full fuel cycle analyses and was developed in a user-friendly Microsoft Excel platform with a graphical user interface.

13. Comprehensive Multi-Modal Truck/ Freight Forecasting Model (Truck, Rail, Air, Distribution Center of Goods Movement)

This model combines elements of two state-of-the-art freight modeling techniques: logistics chain modeling and tour-based truck modeling. The Multi-modal Truck/ Freight Forecasting Model provides a fully calibrated and validated truck/freight forecasting system for the LA five county regions. Large area networks were developed for road and rail; a zone system was created and socioeconomic data were summarized; and base year commodity flow matrices were formed. These data were input to Cube Cargo, and the model was applied to estimate commodity flow matrices by mode and commodity class and truck matrices by truck type. The truck matrices were assigned to the network. The model can be used on urban, regional, and long-distance applications. It estimates origin-destination matrices of the annual tons of goods by commodity class by mode and origin-destination matrices of truck trips by truck type. Cube Cargo also provides matrices of urban service trips to provide a complete estimate of truck flows. This model has been successfully implemented in seven European countries for modeling regional and national freight movements. The LAMTA (Los Angeles Metropolitan Transit Authority, Los Angeles, California) is the first regional transportation-planning agency in the United States to utilize this model.

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